March 2005

Preliminary Assessment of Water Withdrawal Thresholds at Selected U.S. Geological Survey Stream Flow Gages

Prepared by the
Maine Geological Survey, Department of Conservation
for the
Maine Department of Environmental Protection

March 2005

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Introduction:

This draft report provides an initial assessment of the impact of imposing seasonal withdrawal thresholds on pumping water from medium and small sized rivers and streams in Maine.

Objective:

This report presents a graphical comparison of proposed water withdrawal thresholds with daily flow at selected U.S. Geological Survey (USGS) stream flow gages. The USGS stream flow gages have been selected to represent small and medium sized rivers and streams throughout the State. These comparisons provide a way to estimate when water withdrawal from the selected rivers and streams would have been limited during water years 2001 through 2003 (October 1, 2000 through September 30, 2003). The period was selected to include the drought experienced in 2001 and 2002 and the more normal water year 2003.

The times when water withdrawal would have been limited at the selected USGS stream gages are likely to be representative of other small and medium sized rivers and streams throughout the State.

Methodology:

Six USGS stream gages were selected for analysis. These are:

Kingsbury Stream near Abbot Village
Old Stream at Wesley
Stony Brook at East Sebago
Swift River near Roxbury
Wild River at Gilead
Williams Brook at Phair

The stream gage locations are shown on the map on the next page.


Selected USGS Stream Gages
Williams Brook at Phair, Maine
Kingsbury Stream at Abbot Village, Maine
Old Stream near Wesley, Maine
Swift River near Roxbury, Maine
Wild River at Gilead, Maine
Stony Brook at East Sebago, Maine
Explanation
USGS stream gage
Maine Geological Survey, Department of Conservation

The six seasons and associated seasonal withdrawal thresholds proposed in the draft water use rules prepared by the Maine Department of Environmental protection (DEP) in March 2005 are:

January 1 to March 15	February median
March 16 to May 15	April median
May 16 to June 30	June median
July 1 to September 15	August median
September 16 to November 15	October median
November 16 to December 31	December median

The monthly median flows at the USGS stream gages were estimated using regional regression equations developed by the USGS. While actual monthly statistics could have been used for the thresholds, the intent of this assessment is to duplicate the likely scenario for withdrawal at a previously ungaged site.

Statewide regression equations are available for all six thresholds (Dudley, 2003). Regional equations are available for the August median in Aroostook County (Lombard and others, 2003) and Washington County (Lombard, 2004).

The Statewide equations are:

Regression equation	1-sigma average standard error of prediction
$Q_{feb} = 36.54 * A^{1.017} * DIST^{(-0.89)}$	-13.4 to 15.5
$Q_{apr} = 0.227 * A^{1.01} * 10^{(0.028*pptA)}$	-20.8 to 26.2
$Q_{jun} = 0.734 * A^{1.076}$	-22.5 to 29.0
$Q_{aug} = 0.152 * A^{1.12} * 10^{(1.31*SG)}$	-28.6 to 40.2
$Q_{oct} = 0.307 * A^{1.074} * 10^{(1.11*SG)}$	-25.8 to 34.8
$Q_{dec} = 12.00 * A^{1.00} * DIST^{(-0.513)}$	-13.1 to 15.0

where Q is the median flow for the month, A is the drainage basin area in square miles, DIST is the distance from the coast as measured from a line defined in Dudley (2003), pptA is the spatially averaged mean annual precipitation in the basin in inches, and SG is the fraction of the basin underlain by significant sand and gravel aquifer. There is a 68-percent probability that the true monthly median flow will lie within the range of the 1-sigma standard error of prediction of the estimated monthly median flow.

The regional equation for Aroostook County (Lombard and others, 2003) is

$$Q_{aug} = 0.061 * A^{1.28} * 10^{(0.00059*ELEV)}$$

Where Q_{aug} is the estimated August median flow at the site, A is the drainage basin area in square miles, and ELEV is the mean basin elevation above sea level in feet. The 1-

sigma average standard error of prediction for the estimate is from –38 to +62-percent. There is a 68-percent probability that the true August median flow will lie within the range of the 1-sigma standard error of prediction.

The regional equation for Washington County (Lombard, 2004) is

$$Q_{aug} = 0.148 * A^{1.18466} * 10^{(0.409*SG)}$$

Where Q_{aug} is the estimated August median flow at the site, A is the drainage basin area in square miles, and SG is the fraction of the basin underlain by significant sand and gravel aquifer. The 1-sigma average standard error of prediction for the estimate is from –27 to +38-percent. There is a 68-percent probability that the true August median flow will lie within the range of the 1-sigma standard error of prediction.

The basin characteristics for each of the six drainage basins above the USGS stream gages were determined using various GIS datasets, and are summarized in the table below:

Basin Characteristics

		Area (sq mi)	Fraction aquifer	Distance from coast (mi)	Mean annual precipitation (in)	Mean elevation (ft)
Kingsbury Stream near Abbot Village		94.5	0.008	106	45.9	988
Old Stream at Wesley		29.1	0.200	53	45.8	321
Stony Brook at East Sebago		0.81	0.190	55	45.0	366
Swift River near Roxbury		96.7	0.002	110	46.3	1856
Wild River at Gilead		70.0	0.005	94	47.5	1794
Williams Brook at Phair		3.82	0.000	156	35.4	655

For Williams Brook at Phair, the Lombard and other (2003) regional equation for the August median was used to compute the July 1 to September 15 seasonal threshold. For Old Stream at Wesley, the Lombard (2004) regional equation was used to compute the July 1 to September 15 seasonal threshold. For all other stream gages and all other seasonal thresholds, the Dudley (2003) regional equations were used.

The estimated seasonal withdrawal thresholds are summarized in the table below:

Estimated Seasonal Withdrawal Thresholds (cubic feet per second)					
Season	Statistic		Kingsbury Stream near Abbot Village	Old Stream at Wesley	Stony Brook at East Sebago
Jan 1 to Mar 15	February median		58.88	32.83	0.83
Mar 16 to May 15	April median		432.92	130.91	3.34
May 15 to Jun 30	June median		98.01	27.60	0.59
Jul 1 to Sep 15	August median		25.40	9.69	0.21
Sep 16 to Nov 15	October median		41.46	19.11	0.40
Nov 16 to Dec 31	December median		103.77	45.51	1.24
			Swift River near Roxbury	Wild River at Gilead	Williams Brook at Phair
Jan 1 to Mar 15	February median		58.27	48.17	1.59
Mar 16 to May 15	April median		454.68	354.47	8.61
May 15 to Jun 30	June median		100.47	70.96	3.10
Jul 1 to Sep 15	August median		25.61	18.01	0.83
Sep 16 to Nov 15	October median		41.87	29.84	1.30
Nov 16 to Dec 31	December median		104.13	81.63	3.43

It should be noted that the statewide equation from Dudley (2003) is not recommended for use in basins less that 10 square miles in area, so the thresholds estimated for Stony Brook at East Sebago and Williams Brook at Phair have more error than stated in Dudley (2003) and, more importantly, may be systematically higher or lower than the "true" threshold.

The same would hold true for the estimated seasonal withdrawal threshold if any of the basin characteristics used in either the Statewide monthly median regression equations (Dudley, 2003) or the regional August median regression equations (Lombard and other, 2003; Lombard, 2004) fell outside of the range of characteristics used in the regression analysis. In this analysis, no basin characteristic (other than drainage area) used in the calculations was outside of the range of characteristics used in the relevant regression analysis.

Results:

The following hydrographs illustrate when withdrawal of water from the river or stream would be limited at the six USGS stream gage sites for water year 2001, 2002, and 2003. There are 3 graphs for each USGS gaging station – one each for water year 2001, 2002, and 2003. The estimated season thresholds summarized above are shown superimposed on the daily flow at the USGS gaging stations. The shaded areas show times when the daily flow falls below the seasonal threshold.

Water year 2001 should be considered an example of a dry year, with water year 2003 approaching a normal year. Water year 2002 is intermediate between these two, with a very dry early part of the water year.

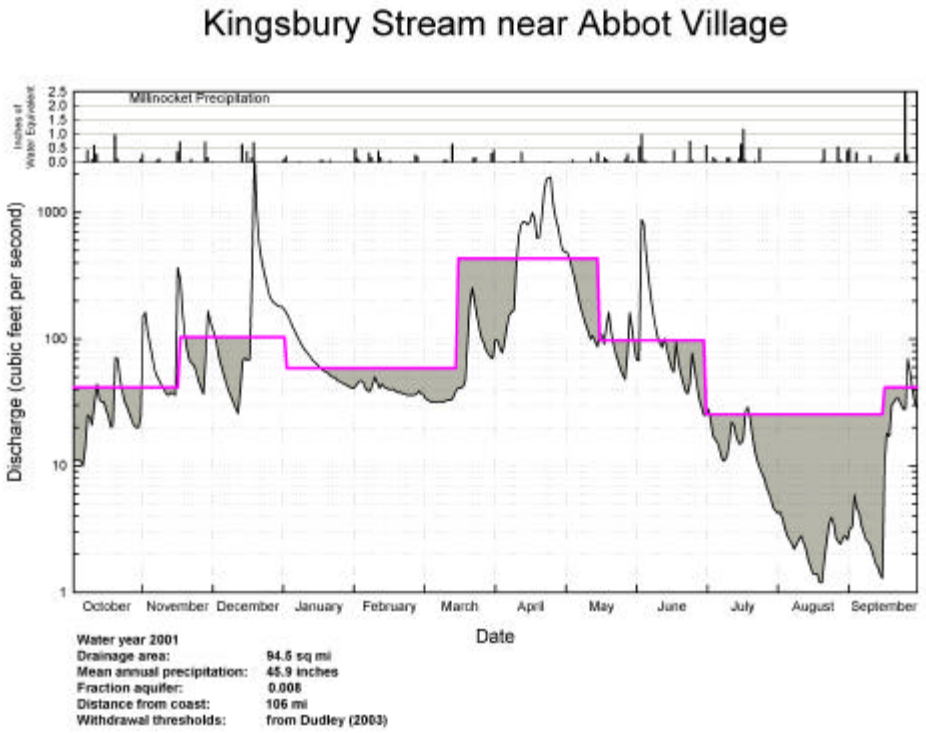
Again, it must be noted that the statewide equation from Dudley (2003) is not recommended for use in basins less that 10 sq mi in area, so the thresholds estimated for Stony Brook at East Sebago and Williams Brook at Phair have more error than stated in Dudley (2003) and, more importantly, may be systematically higher or lower than the "true" threshold.

References:

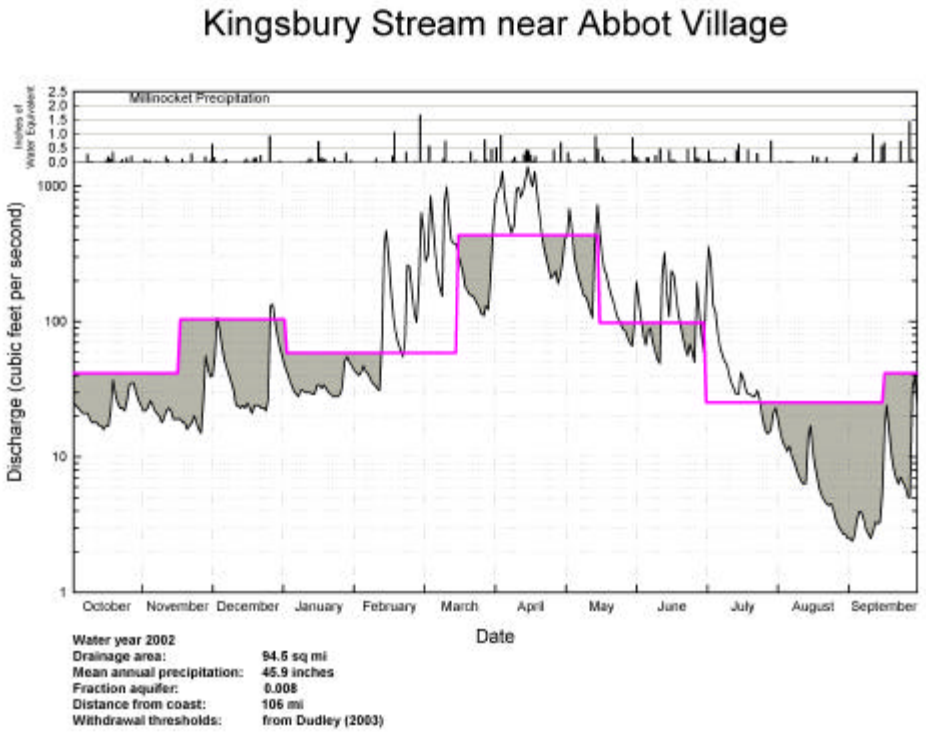
Dudley, Robert W., 2003, Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine, U.S. Geological Survey Scientific Investigations Report 2004-5026, 22p.

Lombard, Pamela J., 2004, August Median Streamflow on Ungaged Streams in Eastern Coastal Maine, U.S. Geological Survey Scientific Investigations Report 2004-5157, 15p.

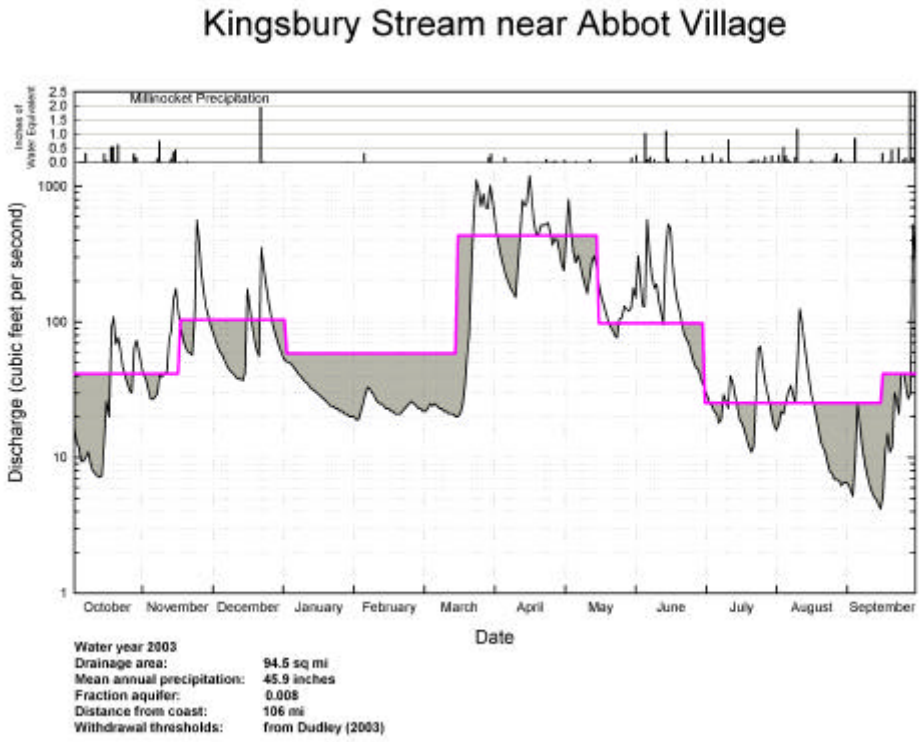
Lombard, Pamela J., Tasker, Gary D., and Nielsen, Martha G., 2003, August Median Streamflow on Ungaged Streams in Eastern Aroostook County, Maine, U.S. Geological Survey Water Resources Investigation Report 03-4225, 20p.



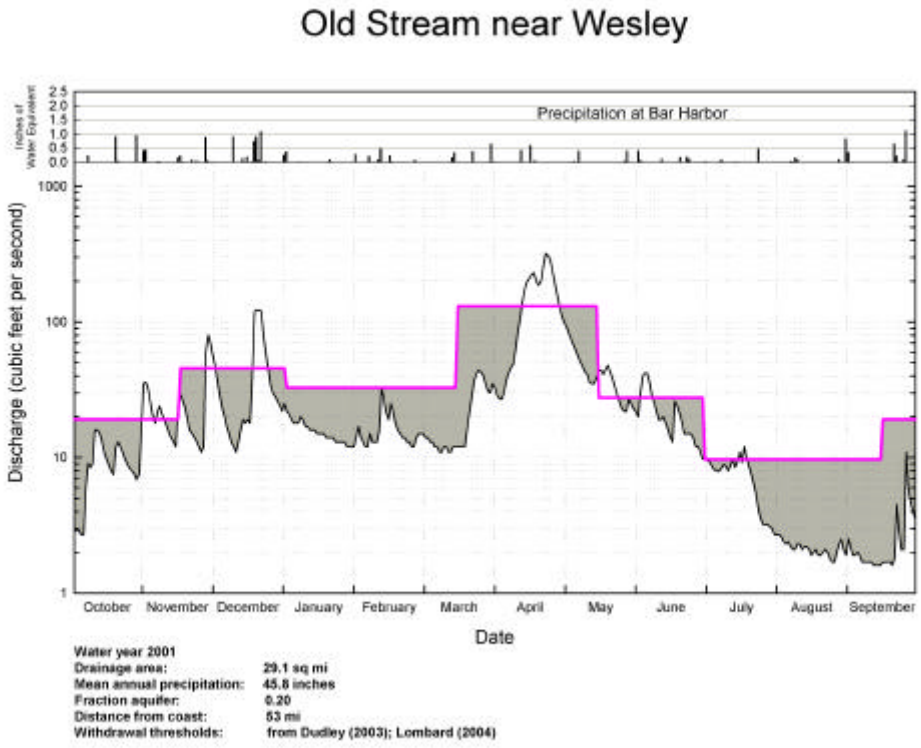
Kingsburg Stream near Abbott Village – Water Year 2001



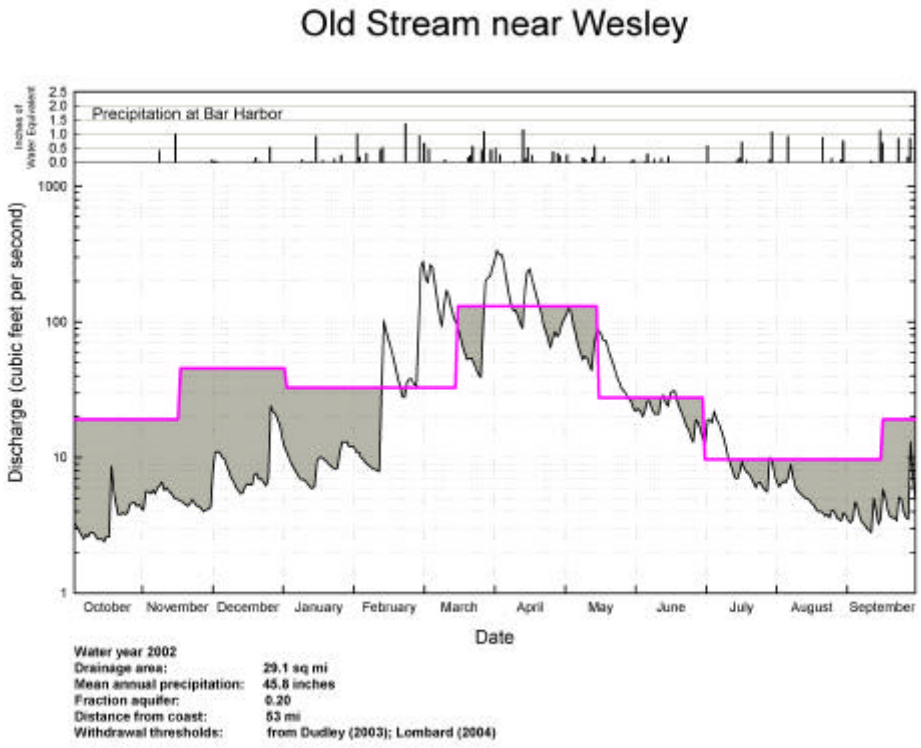
Kingsburg Stream near Abbott Village – Water Year 2002



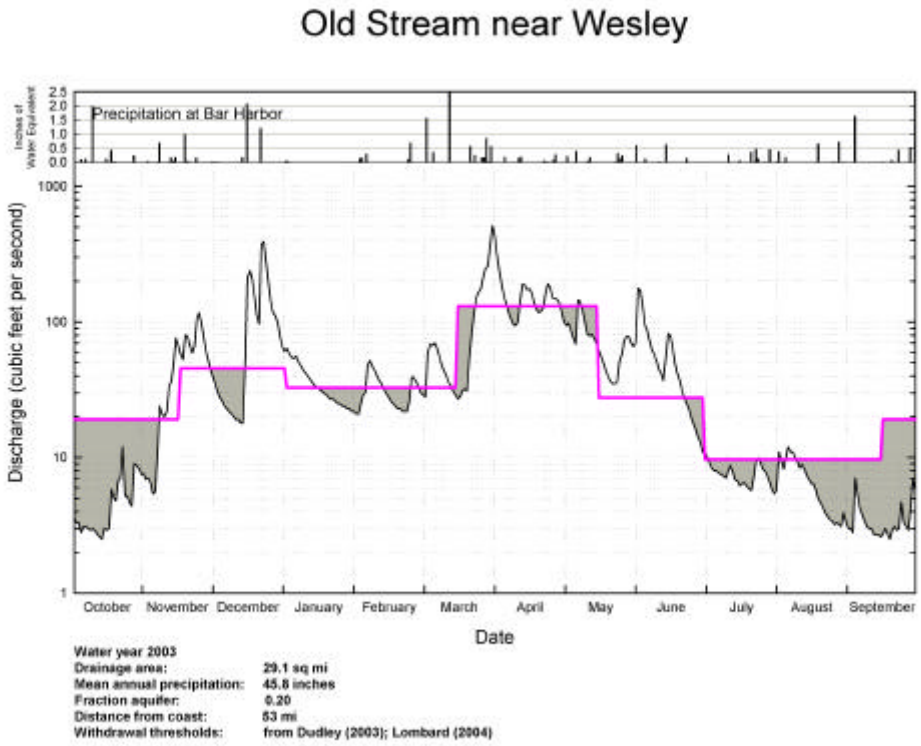
Kingsburg Stream near Abbott Village – Water Year 2003



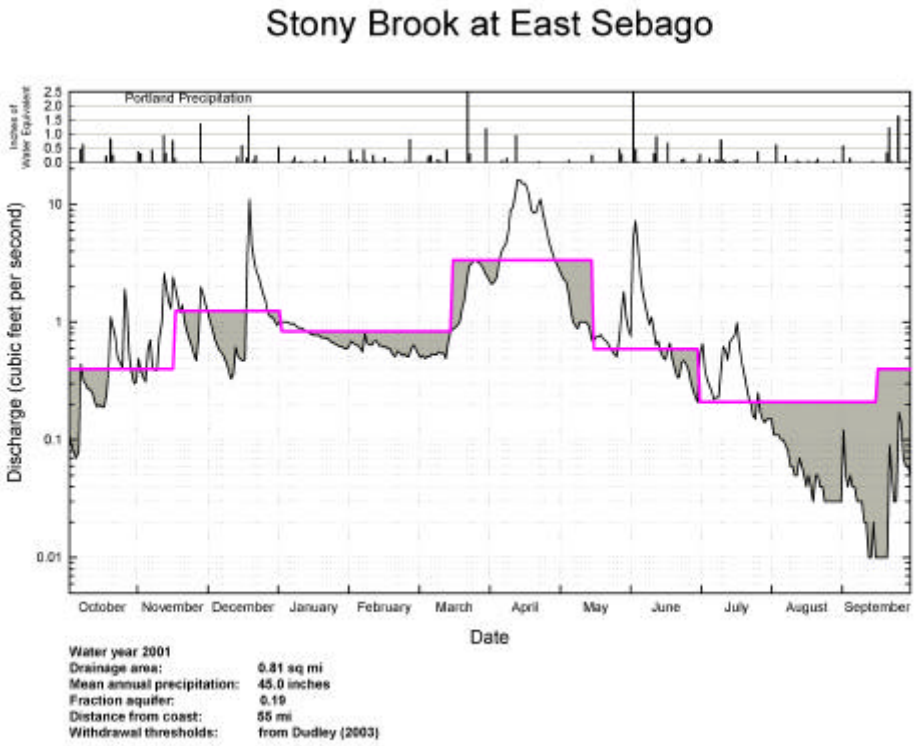
Old Stream near Wesley – Water Year 2001



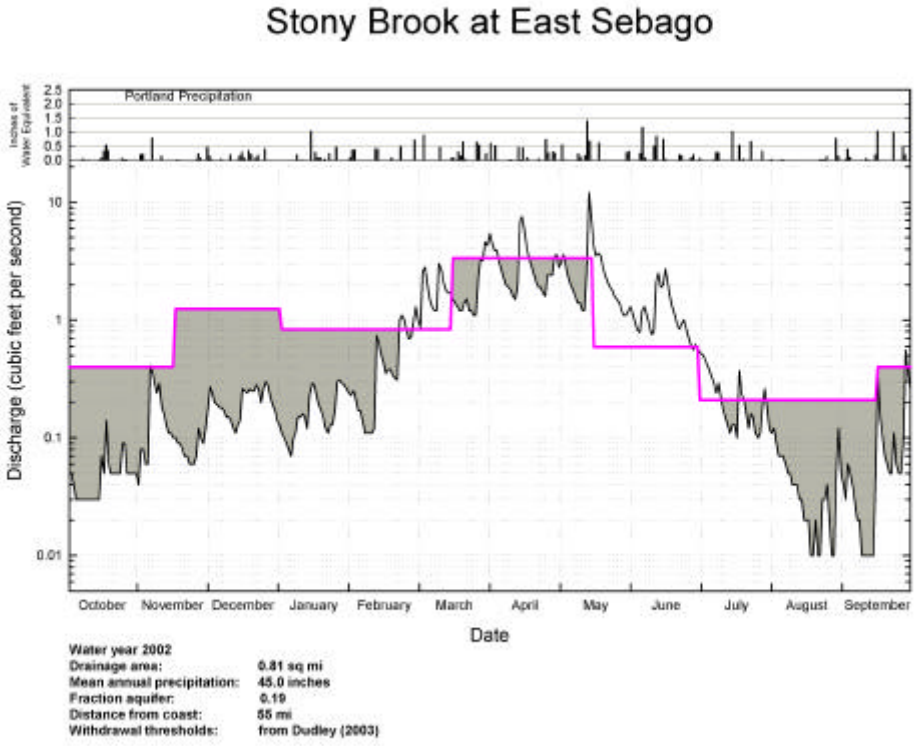
Old Stream near Wesley – Water Year 2002



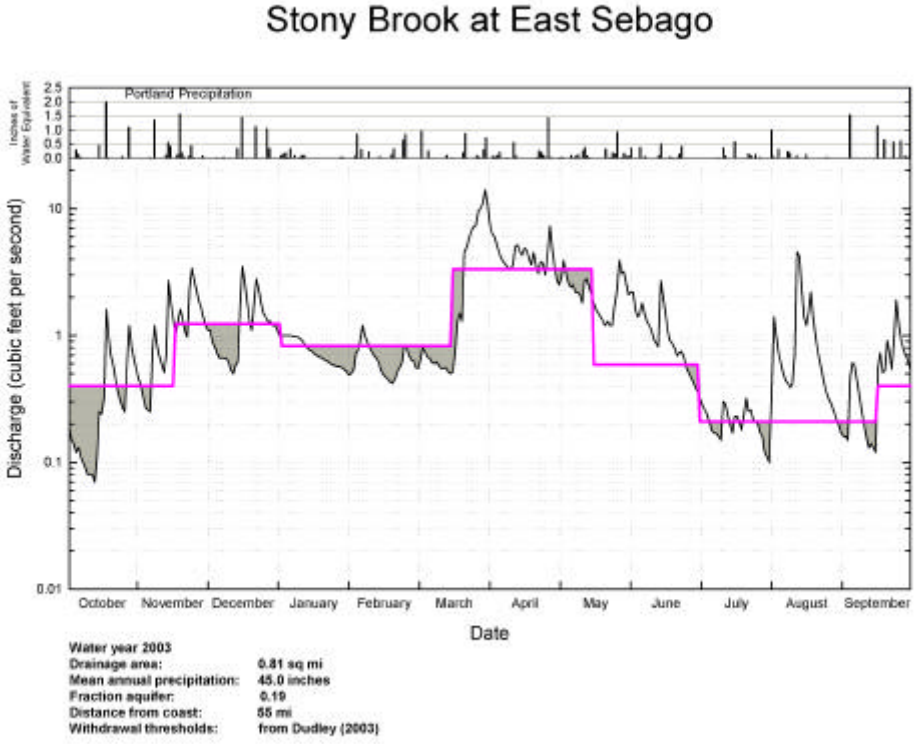
Old Stream near Wesley – Water Year 2003



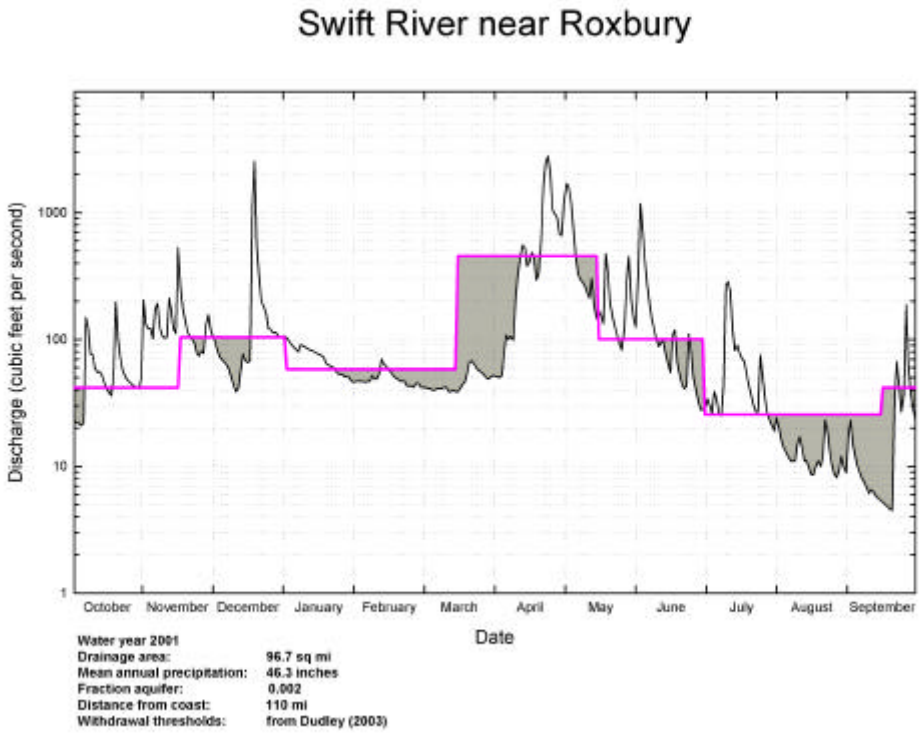
Stony Brook at East Sebago – Water Year 2001



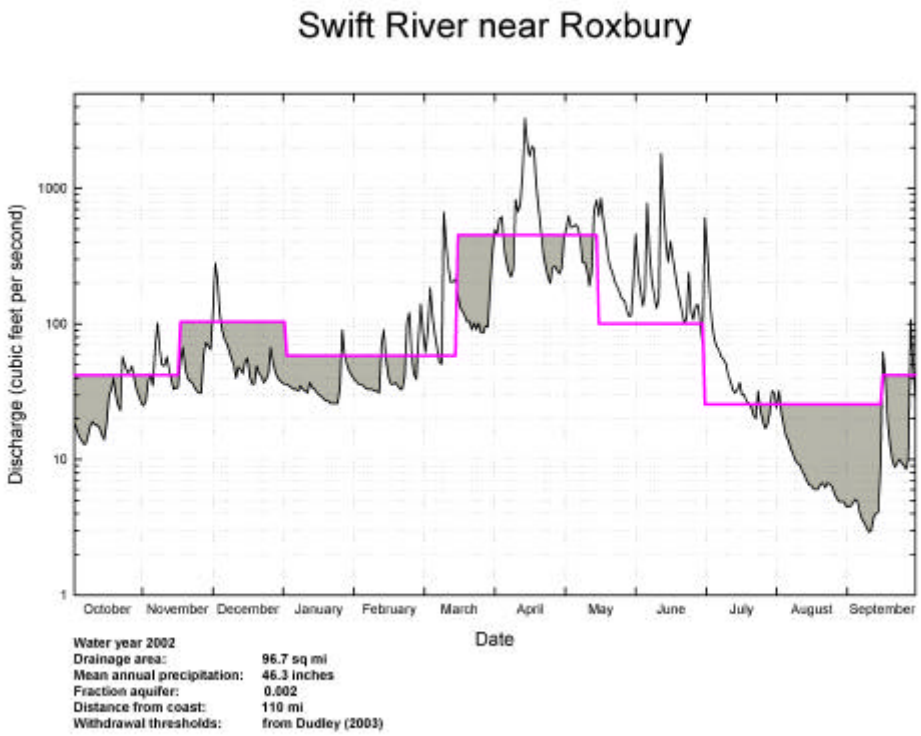
Stony Brook at East Sebago – Water Year 2002



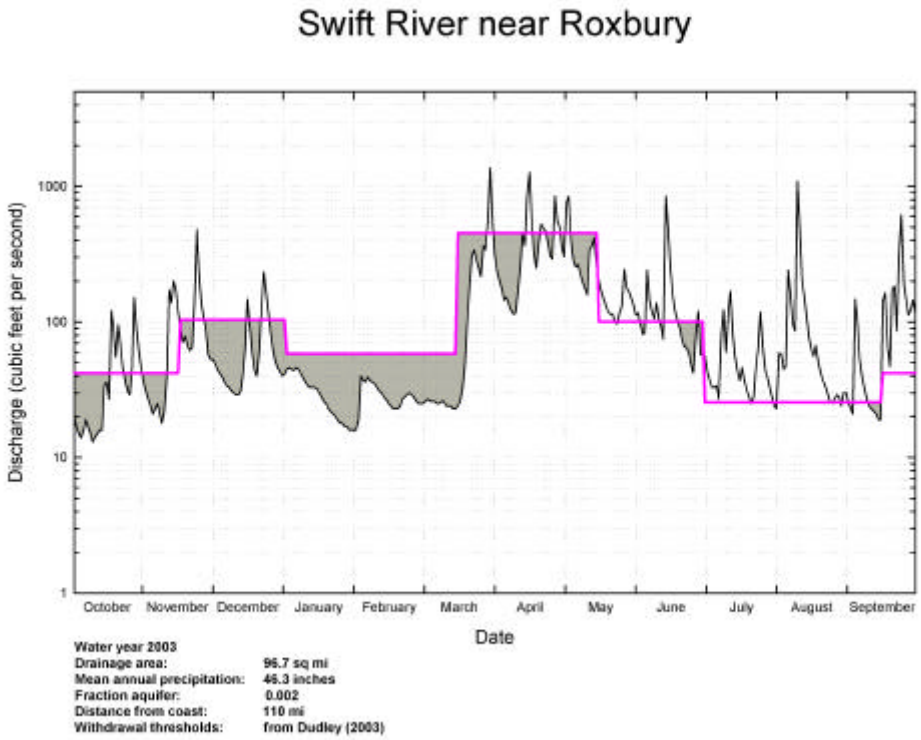
Stony Brook at East Sebago – Water Year 2003



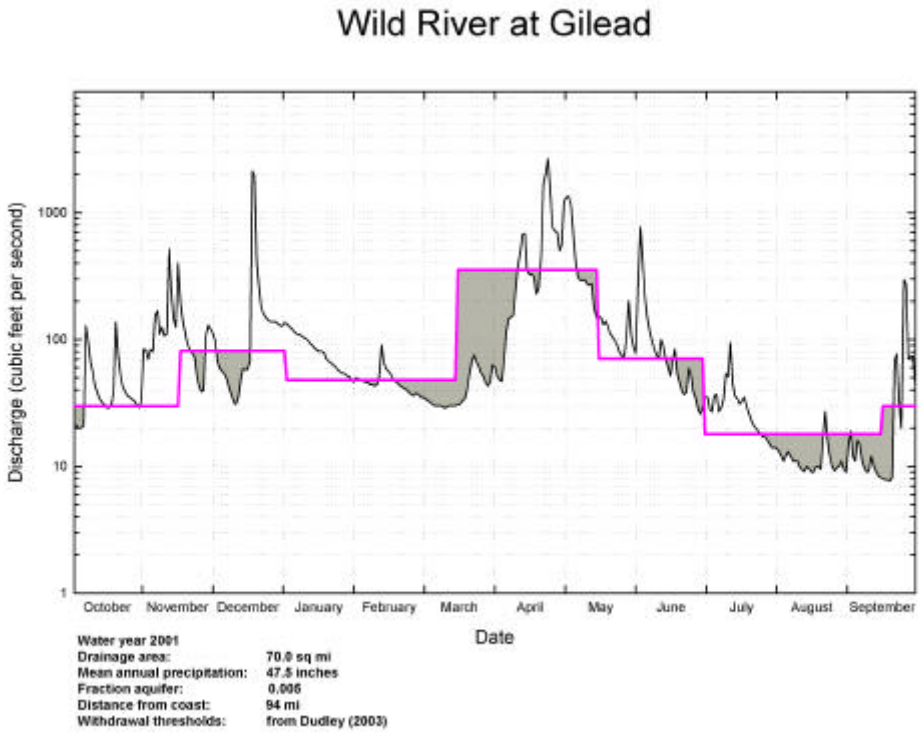
Swift River near Roxbury – Water Year 2001



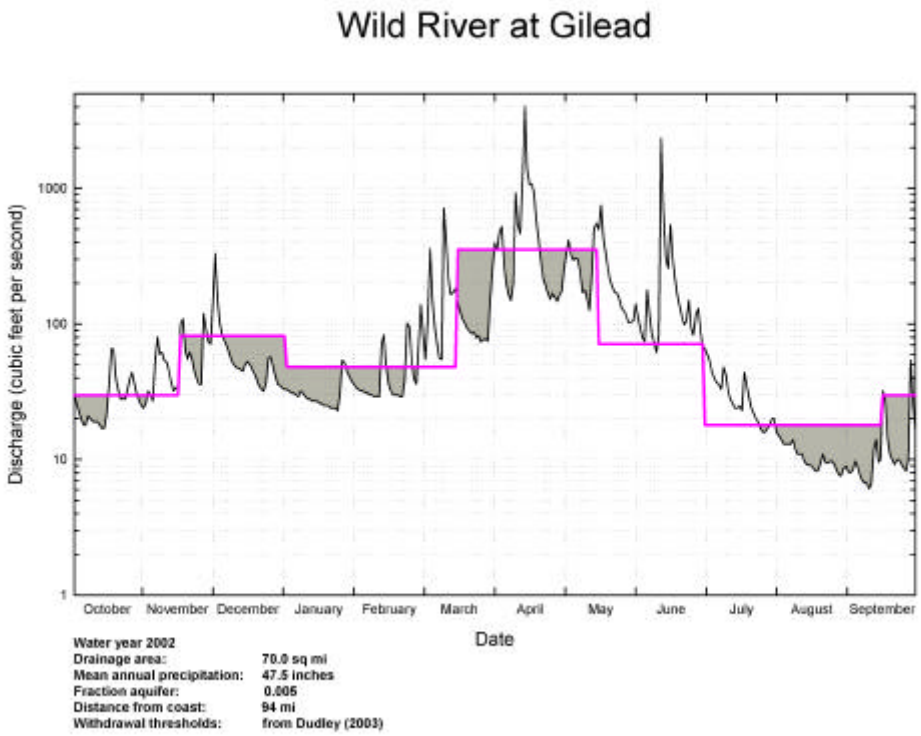
Swift River near Roxbury – Water Year 2002



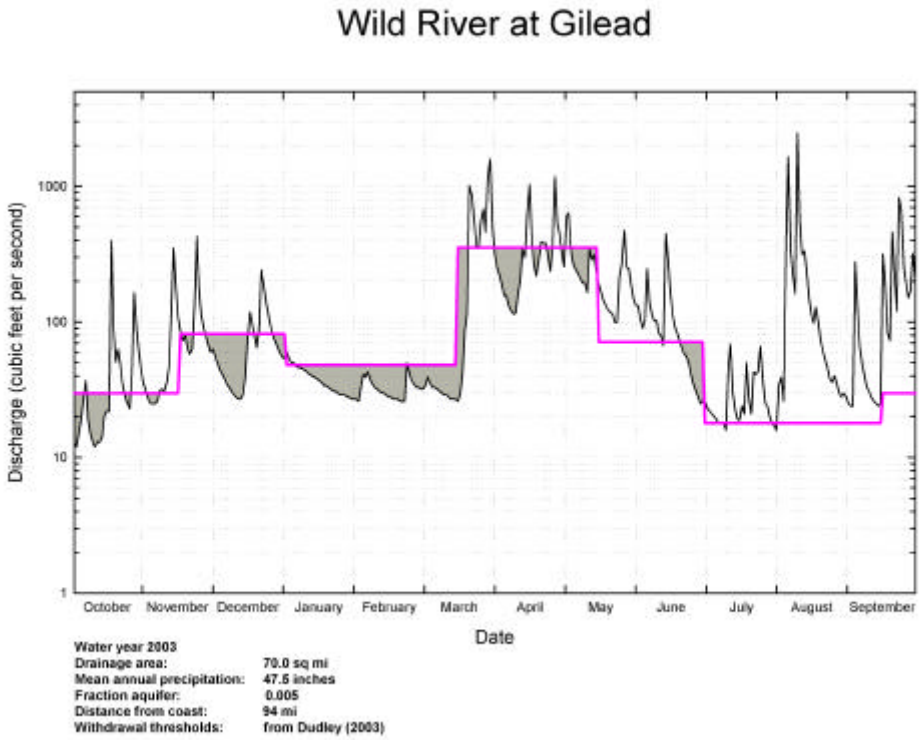
Swift River near Roxbury – Water Year 2003



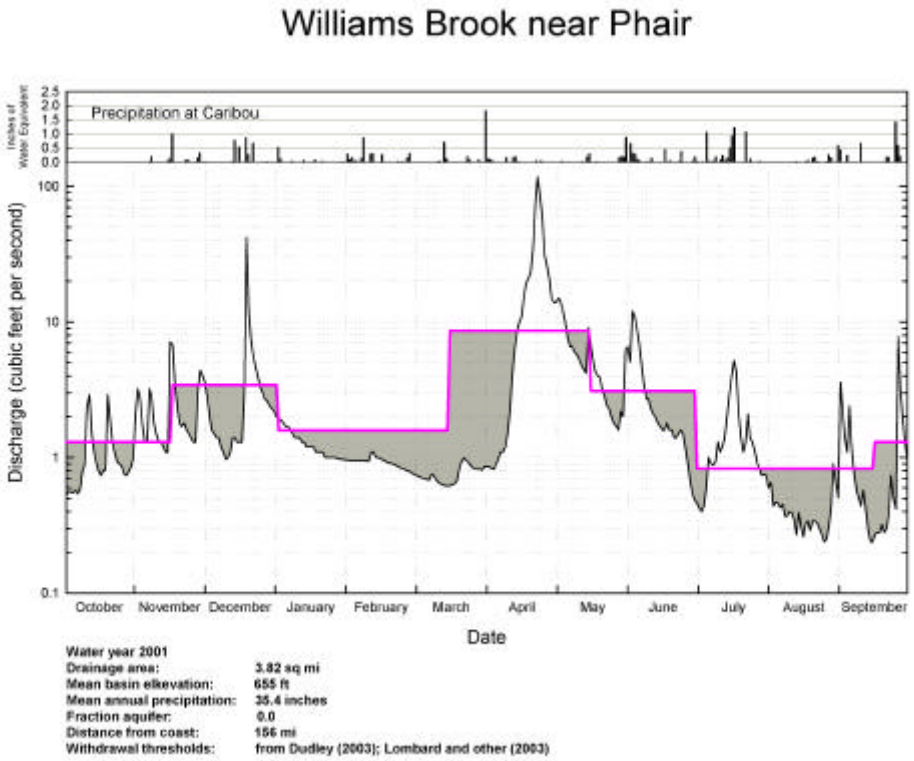
Wild River at Gilead – Water Year 2001



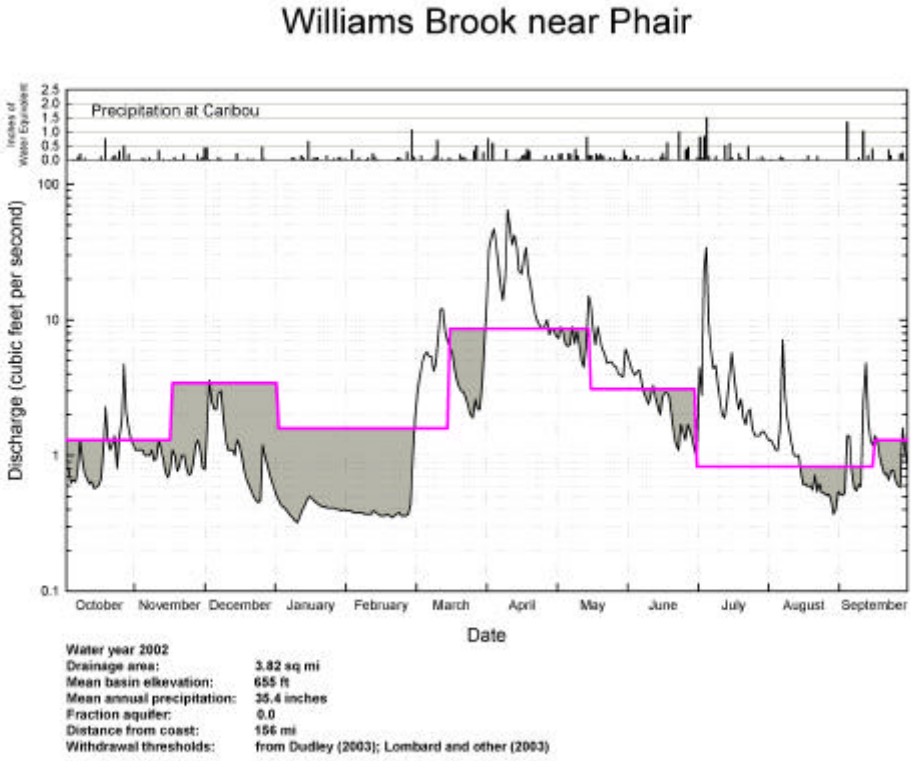
Wild River at Gilead – Water Year 2002



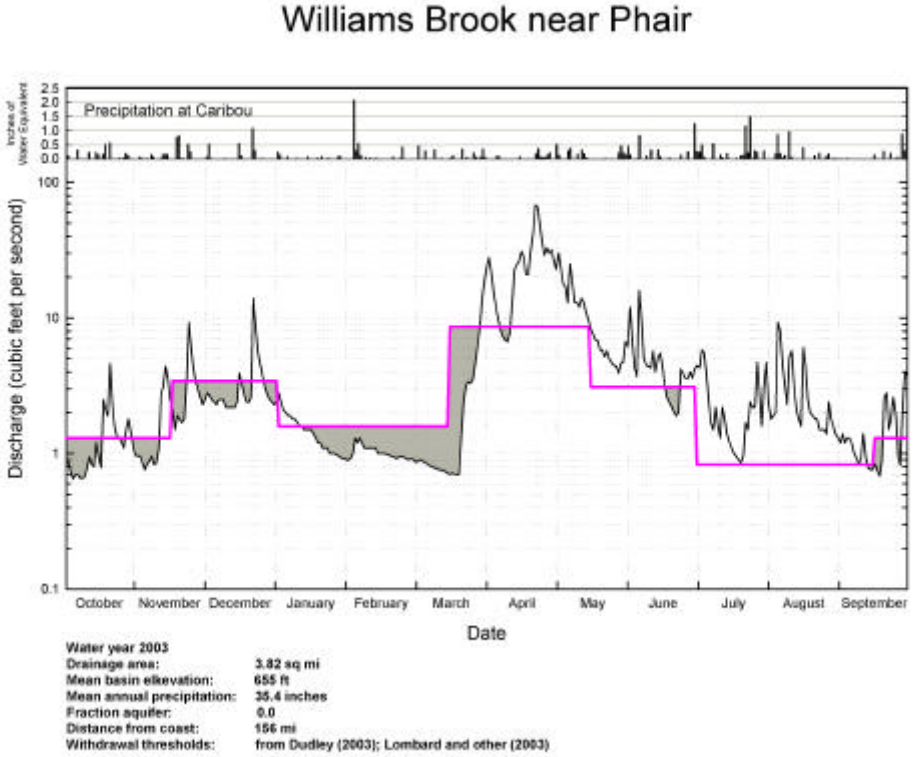
Wild River at Gilead – Water Year 2003



Williams Brook at Phair – Water Year 2001



William Brook at Phair – Water Year 2002



Williams Brook at Phair – Water Year 2003